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THE DETERMINATION OF THE CAUSES FOR PREMATURE RELEASE FROM THE ARRAY OF CAST CYLPEBS MADE FROM WHITE HIGH CHROMOUS CAST IRON AND THEIR SUBSEQUENT THERMAL TREATMENT

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Abstract
This article discusses the causes of premature failure of the drum cast cylpebs made of a white high chrome cast iron LLC «Dalvarzinsky repair factory». Theoretical and practical basics of preparation and receipt of cylpebs by casting in earthen form were observed. In the article is presented the best option of the chemical composition of cast iron ICHH28N2 brand and its mechanical properties-hardness of iron, optimal thermal treatment with a double phase recrystallization for cast cylpebs are presented. The composition and properties of the iron before and after heat treatment are studied. The final heat treatment mode, increasing hardness and wear resistance of cast cylpebs in two or more times are proposed.

Keywords: white high chrome cast iron, chemical composition, heat treatment, hardness, abrasive wear resistance.

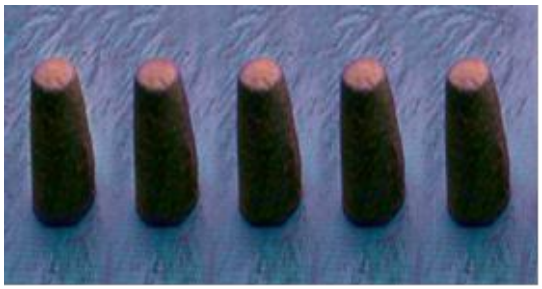
1. INTRODUCTION

Recommendations on the literary information [1, 2], which currently testifies that most of the cast drum cylpebs cement production fail by surface abrasion. The expenses for repair or restoration republic tens of billions sum. In these circumstances, cost-effective is any prolongation of castings by increasing their durability and longevity, as repair and restoration of details do not always provide the necessary quality of products [3].

In recent times the Republic of Uzbekistan is quicken the pace of development of cement production that is connected with the increase of demand for materials and products, including construction purposes, have to meet strict quality requirements. The further development of cement production requires various high quality of details of machines and equipment that lengthen life of the of these products.In this regard, receipt of new products and the improvement of manufacturing technologies of cement and building materials are very actual.

This paper presents the results from industrial and scientific research on the causes of premature release of cast iron drum type cylpebs [4] made of in the form of earth in the foundry plant, LLC «Dalvarzinsky repair factory». In the foundry plant iron cylpebs are produced (fig.1) brand ICHH28N2 (H28N2). This detail is during the constant rotation in large drums within 180-216 hours quickly wears out and becomes unusable. Currently, between the department «Materials science and technology of materials» Mechanical engineering faculty of the Tashkent State Technical University (TashGTU) and «Dalvarzinsky repair factory» (DRZ) conduct research and development and production work on identifying the main causes of release structure and increase of wear resistance of two times or more by heat treatment.

a)



b)

Fig.1. *General view of the cast drum type cylpebs made of high chromium white iron brand ICHH28N2: **a**-molding techniques and getting cast cylpebs; **b**-ready cylpebs after heat treatment with a double phase recrystallization*

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The aim of this work is the determination of the chemical composition and mechanical properties, as well as improving working capacity and increasing hardness and wear resistance of cast cylpebs manufactured in the form of white earthen high chrome cast iron in the foundry plant LLC «Dalvarzinsky repair factory» and their subsequent heat treatment with a double phase recrystallization [5,6].

2. The method of the research

The object of the research is cast samples size of 15x15x15, 20x20x15 and 65x30x15 mm cut from a high chromium white iron drum type cylpebs imported «Warman» and local production of LLC «DRZ» in order to compare the mechanical properties. All sample sizes to conduct macro - and microstructural analyzes. In these works disadvantages of production technology of foundry LLC «DRZ» are:

1) the chemical composition of white iron brand ICHH28N2 does not match state standards;

2) low hardness of white iron HRC = 42-45;

3) low wear resistance and durability of white iron up to 180-216 hours;

4) does not respond metallographic microstructure of iron requirements.

The chemical composition of the investigated samples is a of white iron in table 1. These results show that all melting on the basic elements may be related to the well-known brands of cast iron [2], but there are the following differences:

- melting number №1 has obviously exaggerated content of carbon and nickel for brand ICHH28N2;

- melting №2,3 have less than a high content of carbon, chromium, nickel and more;

- sulfur content in all batches of LLC (DRZ) several times more than in cast iron «Warman».

Ready cast cylpebs made of white high chrome cast iron for stress relief, improvement of machinability and preparation of structure for hardening heat treatment [6], is subjected to soft annealing at 700-730^0 C for a few hours, followed by cooling in the furnace on the hardness of 39-46 = HRC.

Table 1

The chemical composition of the investigated samples of white iron

Product, founding	Content of elements, mass %								
	C	Si	Mn	P	S	Cr	Ni	Mo	Cu
Operating cylpebs (Warman)	2,87	0,317	1,38	0,031	0,012	28,31	0,53	0,049	0,025
Operating cylpebs LLC (DRZ)	2,45	0,59	0,65	0,089	0,071	22,87	1,26	-	-
Founding №1 LLC (DRZ)	3,49	0,51	0,57	0,067	0,032	28,86	1,54	0,057	0,2
Founding №2 LLC (ДРЗ)	2,99	0,87	0,62	0,064	0,03	26,54	0,99	0,059	0,26
Founding №3 LLC (DRZ)	2,92	1,35	0,33	0,036	0,035	23,0	1,16	0,053	0,22

In the experiments samples of iron were subjected to annealing at 700^0 C within 2 hours, followed by cooling with the furnace. The results of these experiments are shown in table 2.

Table 2

Chemical elements and hardness of the samples

Product, founding	Main elements, %					ΣC, Ni, Si	Hardness HRC		Difference in HRC
	C	Cr	Ni	Mn	Si		before annealing	annealing	
Operating cylpebs (Warman)	2,87	28,31	0,53	1,38	0,317	3,22	57	44	13
Operating cylpebs LLC (DRZ)	2,45	22,87	1,26	0,65	0,59	4,3	50	43,5	6,5
Founding №1 LLC (DRZ)	3,49	28,86	1,54	0,57	0,51	5,54	50	49,66	0,34
Founding №2 LLC (DRZ)	2,89	26,54	0,99	0,62	0,78	4,76	53,5	42,7	10,8
Founding №3 LLC (DRZ)	2,92	23,0	1,16	0,33	1,35	5,43	55	51	4

As you can see from the presented data, the hardness after annealing 700^0 C within the meaning of HRC = 39-46 is not achieved in all foundings.

In the high chromium cast iron containing about 28-30% Cr, with increasing the carbon content in γ-region expands and the amount of ferrite is reduced in the structure of the substrate. However, γ-region expands nickel and silicon impedes carbon diffusion and decomposition of solid solutions. Because it has been found that the total content of the elements should be about 4,5% (C, Ni, Si).

3. RESEARCH RESULTS AND DISCUSSION:

To get comparable results on wear resistance of the material structure and parameters of production «Warman» and LLC (DRZ) of working cylpebs, overage operation, and special samples were cut. Micro researches, the analysis of the phase X-ray, the measurement of hardness and microhardness of samples were carried out. In both cases the macrostructure of iron had columnar structure: carbide crystals are perpendicular on the surface of the form and have the structure close to the eutectic. Dimensions of carbide particles in a cross section appeared to be close. The differences were observed in the amount of residual austenite, the microhardness of the dislocation density in the base metal phase and the α-total hardness (table 3).

Table 3

The microhardness, dislocation density and the amount of residual austenite

Operating cylpebs (cast iron)	Microhardness HV_{100}, кг/мм^2		Dislocation density $\rho \cdot 10^{11}$, 1/см^2	Residual austenite, %	Hardness, HRC
	basis	carbide			
(Warman)	600	1230-2100	2,36	17	57,28
LLC (DRZ)	543	1290	0,5	58	51

Abrasion test [7] was carried out on the machine ПВ-7 in terms of friction, the slip of polyurethane roller modeled

in the presence of loose abrasive - ground pulverized quartz. Amount of wear was determined by weight loss. During the wear testing meant that the abrasive wear resistance depends on hardness and the residual austenite can greatly improve wear resistance if it is not stable [8].

Macrostructure of cast iron in the fracture had a an obvious columnar character when crystals of iron on the long axis perpendicular to the primary drum type cylpebs, ie growth of the crystal during the solidification of cast iron was mostly in the direction of a quick cooling. Therefore, for thin sections were prepared for the researches as the long transverse axis of the crystals, and along it. Macro-analysis was studied on a macroscopic microscope MBS-9.

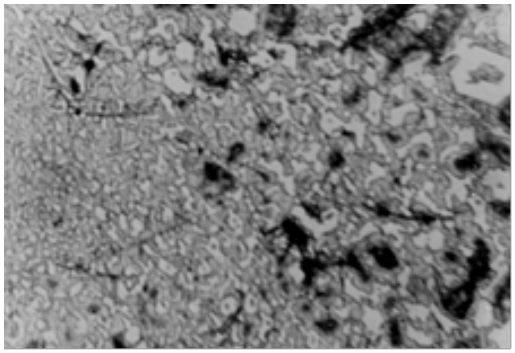
The results of the research show that the surface conditions of the samples of imported iron «Warman» on the friction surfaces had a subtle furrow, impact the abrasive particles and some deep scratches occur occasionally. On the friction surface of the samples of local iron produced by LLC «DRZ» there are a lot of deep scratch traces of «gouge» with abrasive particles. In addition, it is clearly visible areas of brittle spalling in the form of pits, on a longitudinal microsection there are more brittle spalling areas of the sample. On the friction surfaces of the longitudinal samples it was observed not only gouge deep furrows, but also very strong traces of chipping along the fiber structure - the long axis of the carbides. This is connected with a presence of white iron sulfides in large amounts, which was proved experimental researches carried out by the authors. It testifies that in the chemical composition of high chromium white cast iron the content of sulfur is five times greater than the composition of the imported cast iron «Warman» [4,5].

These cast irons should be heat-resistant, oxidation resistance, crack resistance and corrosion resistant in high temperatures. To improve the heat resistance of cast iron, first of all it is annealed and normalized at a certain temperature with cooling in air and tempering. As for the resistant to corrosion of cast iron doped silicon and chromium is used. They have a high corrosion resistance in sulfuric acid, nitric acid and number of organic acids. To improve the corrosion resistance of cast iron they are alloyed with molybdenum or chromium, which not only improves the corrosion resistance but it improves strength and durability. To increase the hardness, strength and wear resistance of cast iron special thermal treatment is used - first normalization, and then mechanical treatment - quenching and tempering of finished parts [9].

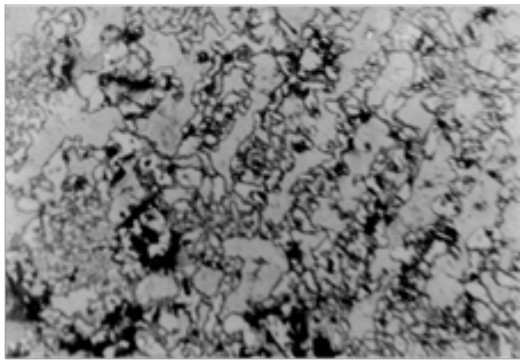
Microstructural analysis was performed on 21 Neofot-German and Russian MIM-8 metallographic microscope. For the etching of microsections reagent of the following composition was used: 1) the ferric chloride - 1.25 g; 2) picric acid - 2.5 g; 3) hydrochloric acid - 1 ml; 4) ethyl alcohol - 45 ml. Metallographic analysis the type of structure, the size of carbide particles and structural components of cast iron were determined [10].

Metallographic researches showed that reporting high chrome white iron of local production of LLC «DRZ» has a composition close to the eutectic, on the cross-sections with small carbide particles whose sizes vary within 8,6-51 microns (fig.2,a,b). The tendency to brittle spalling was found out during the preparation of microsection (fig. 2).

On the longitudinal microsections the tendency to brittle spalling appears strongly (fig. 3,a). At high magnification it is found that chipping is on the alloy matrix, where quite a lot of sulfides (fig. 3,b). Spalling of sulfide particles (light gray) forms a zone of weakness along the boundaries of iron phases - carbides (fig. 4,a). This microstructure is also clearly seen in transverse section (fig.4,b) [5,6].

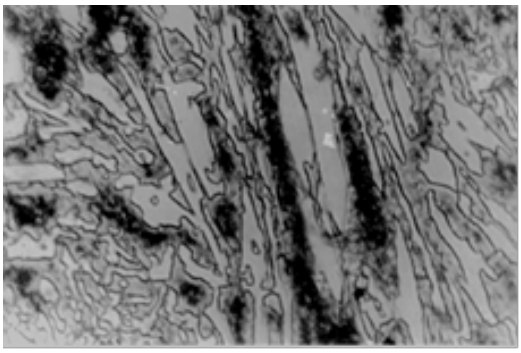


a)

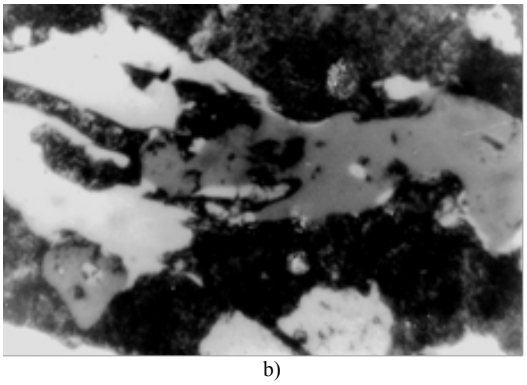


b)

Fig.2. *Transverse sections with small carbide particles (**a**, **b**) X300*

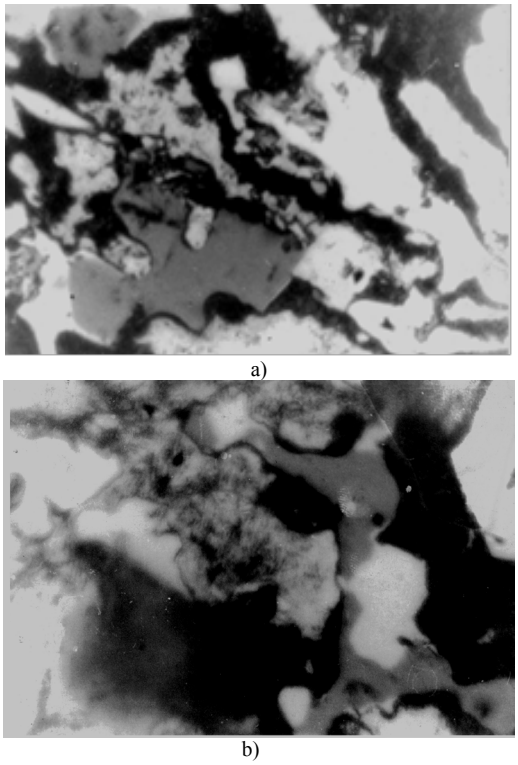


a)



b)

Fig.3. *Longitudinal microsection with a brittle spalling (**a**) X300, there are many sulfides in the structure (**b**) X1700*



a)

b)

Fig.4. *Spalling of sulfide particles and the formation of a weak zone along the boundaries of phases (**a**) and microstructure of sulfide particle phase-iron carbides (**b**) X1700*

Previously developed and new advanced modes of thermal treatment with a double phase recrystallization were used for an experimental batch of products. Production testing results were quite satisfactory and meet the requirements of production [5].

After adjustment and optimization of chemical composition and thermal treatment of double phase recrystallization of high chromium white cast iron (soft annealed 720-740^0 C, 1000-1100^0 C normalization, the intermediate 450-600^0 C holiday, the second normalization 920-940^0 C, 250-300^0 C vacation), period of work has increased more than 624 hours, and surface hardness of HRC = 58-62. It meansthat after the thermal treatment of double phase recrystallization [5] durability increased more than two or three times comparison with «Warman» [6]. The life of cast cylpebs made of white iron of import manufacture «Warman» reaches 350-400 hours.

White cast iron is a very valuable material for the details which work in corrosive atmosphere, high temperature and abrasive wear. Especially high chrome cast iron possesses considerable chemical resistance in oxygenated atmosphere - nitric, phosphoric, and concentrated sulfuric acids, many organic acids, alkali solutions, and salts thereof and industrial waters. Due to high mechanical properties, good density, durability and heat resistance of indicated cast iron they are used for some special purposes (many drum parts cylpebs made of centrifugal pumps, reactors and capacitors)that work under conditions of abrasion, in the fast flowing liquids by heating to 1000^0 C, in furnace gases. The main features of the crystallization of chromium cast iron are the formation of solid solutions and cementite, and when the content of more than 3% of Cr special carbides and solid, non-magnetic and brittle intermetallic Fe-Cr, containing 28% Cr and known as σ-phase. Chrome cast iron is mainly used as wear-resistant, heat-resistant and corrosion resistant materials. Therefore, high-chromium white cast iron is a very valuable material for cast components of drum cylpebs working under abrasive-corrosive wear [4].

At the present time it is hold a scientific research and experimental work on the determination of chemical composition and fur composition, macro - and micro-structure, hardness and microhardness of transverse and longitudinal microsections, abrasion testing before and after thermal treatment of double phase recrystallization (single and double quenching). Also it is investigated the phase X-ray analysis to determine the phase composition of high chromium white cast iron and the defect level of the crystal structure of the matrix alloy, and also determined the dislocation density of white iron.

4. CONCLUSION

In conclusion, it should be noted that the selected optimal modes of thermal treatment with a double phase recrystallization of for drum cast cylpebs increase period of work and durability two or more times. Thermal treatment with double quenching affectsgreatly on the hardness and wear resistance of cast cylpebs. This is important for some parts of cement production and maintenance machinery and equipment. Thermal treatment of high chromium cast cylpebs made of hard alloy which was carried out with double phase recrystallization, forms an optimal structure with a high dislocation density, secondary dispersed and primary coagulated carbides. Therefore, heat treatment with a double phase recrystallization of [5,6] increases the hardness and abrasive wear resistance of two or three times.

In that way, manufacturing technology of drum cylpebs made of cast, in the form of an earthen high chromium white iron ICHH28N2 brands which was developed by the authors, including their subsequent heat treatment with double phase recrystallization, was used for the production of an experimental batch of parts and tested under the conditions of cement production. Test results showed that the wear resistance of cast cylpebs is 2-3 times higher than imported products. This developed technology is implemented in the production of LLC «Dalvarzinsky repair factory» with good economic effect.

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